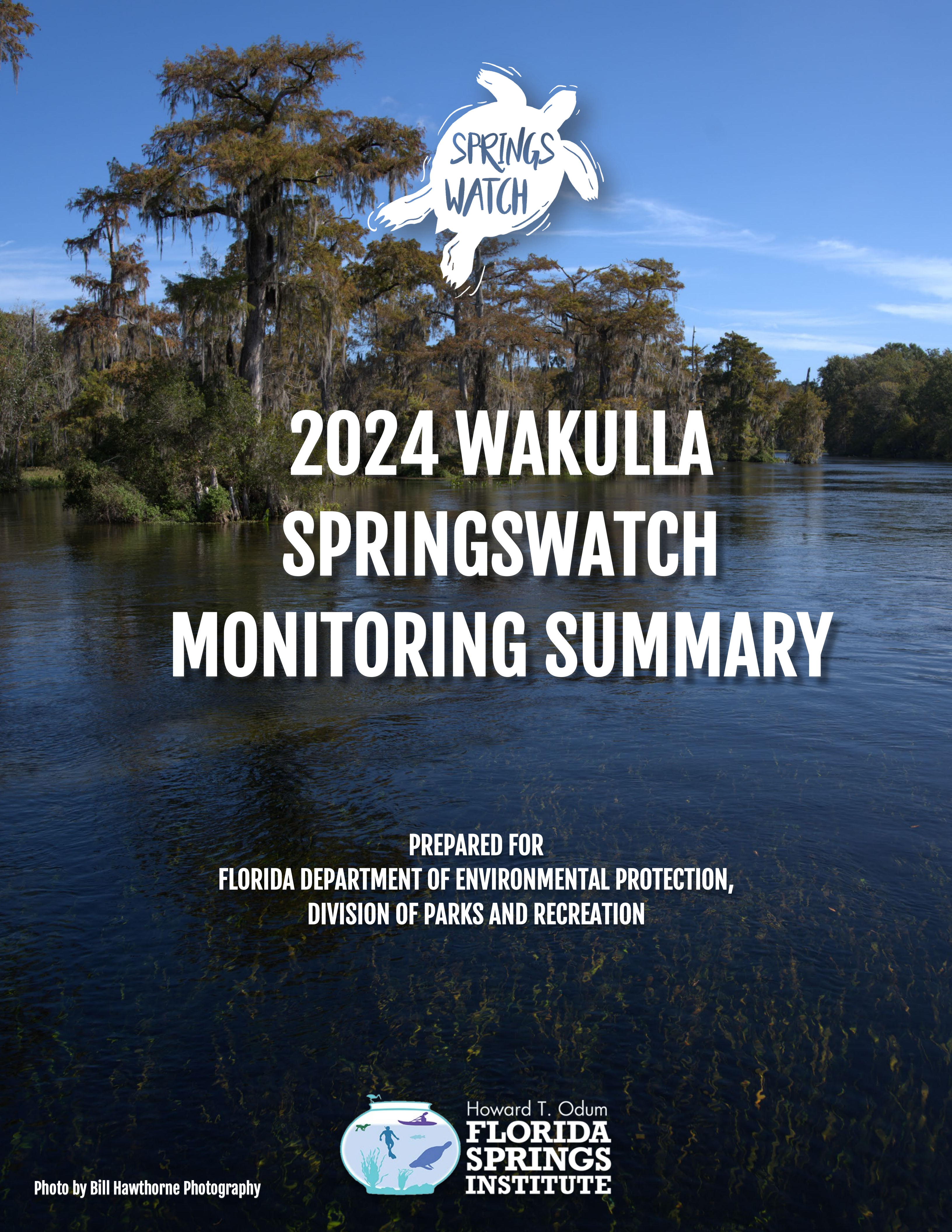


2024 WAKULLA SPRINGSWATCH MONITORING SUMMARY

PREPARED FOR
FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION,
DIVISION OF PARKS AND RECREATION

Howard T. Odum
FLORIDA SPRINGS INSTITUTE

Photo by Bill Hawthorne Photography

Volunteer and Staff Acknowledgments

This report was prepared by the Howard T. Odum Florida Springs Institute (FSI). Ecological monitoring was conducted by FSI staff and the Florida SpringsWatch volunteers under the Florida Department of Environmental Protection (FDEP) Division of Recreation and Parks Research/Collection Permit Number 07012340 and 09132401.

Our Wakulla SpringsWatch program would not be possible without the hard work of our team leader, Sean McGlynn, Edward Ball Wakulla Springs State Park boat captains, and a dedicated team of volunteers: Ken Beattie, Sue Danon, Anton Hanna, Kellie Keys, Brian Lupiani, Cassie McGlynn, Julia McGlynn, Scott Roykance, Cal Jamison, David Shepard, Iris Lee, Russ Shepard, and Kaden Gould. Together they put in 149 volunteer hours over 12 monitoring sessions in 2024. We would like to thank Isaac Szabo for his underwater fish photography utilized in this report and to Bill Hawthorne Photography for providing both the cover photo and volunteer photos.

We thank FSI's SpringsWatch Coordinator, Emanuela Torres-Marquis. We also thank FSI Environmental Scientist, Bill Hawthorne, for program support and for photography of the volunteers and the cover image utilized in this report. We are grateful to Environmental Scientists Thomas "TJ" Comer and Sky Notestein for their contributions, as well as to all staff working under the direction of FSI Director, Haley Moody. Finally, we acknowledge the ongoing guidance provided by FSI founder, Dr. Robert Knight.




Section 1.0 Introduction

1.1 Site Overview

Located 16 miles south of Tallahassee, Wakulla Spring is one of the largest first-magnitude artesian springs in Florida and the United States. Wakulla Spring lies within the Edward Ball Wakulla Springs State Park, which is listed on the Natural Register of Historic Places and is designated a National Natural Landmark. Wakulla Spring forms the headwaters of the Wakulla River, which flows for nearly 11 miles before merging with the St. Marks River in the town of St. Marks. Wakulla Springs is renowned for its natural beauty and has been a favorite recreational site, as well as potable water source, for residents of Leon, Wakulla, and surrounding counties. However, the river and springs have not been immune to human impacts, demonstrating reductions/reversals in flow, elevated nitrate nitrogen, increased dark-water days, and increased growth of invasive hydrilla and filamentous algae.

FSI's SpringsWatch volunteer citizen-science program has provided enhanced monitoring of the Wakulla River and springs ecological health since 2019. The resulting data are provided in annual reports and via the SpringsWatch website (floridaspringsinstitute.org/springswatch) to inform the state's environmental agencies and educate the public about the springs and river's health.

This report was prepared by the Howard T. Odum Florida Springs Institute and is focused on 2024 ecological monitoring along the Wakulla River and springs conducted by SpringsWatch volunteers.

1.2 Monitoring Stations

Figure 1 shows the nine SpringsWatch monitoring stations along the Wakulla River. WAK-HS represents the head spring; WAK-1 through WAK-8 denotes river stations. A summary of all sampling sites, their station names, latitude, and longitude used within the Wakulla SpringsWatch groups can be viewed in Table 1.

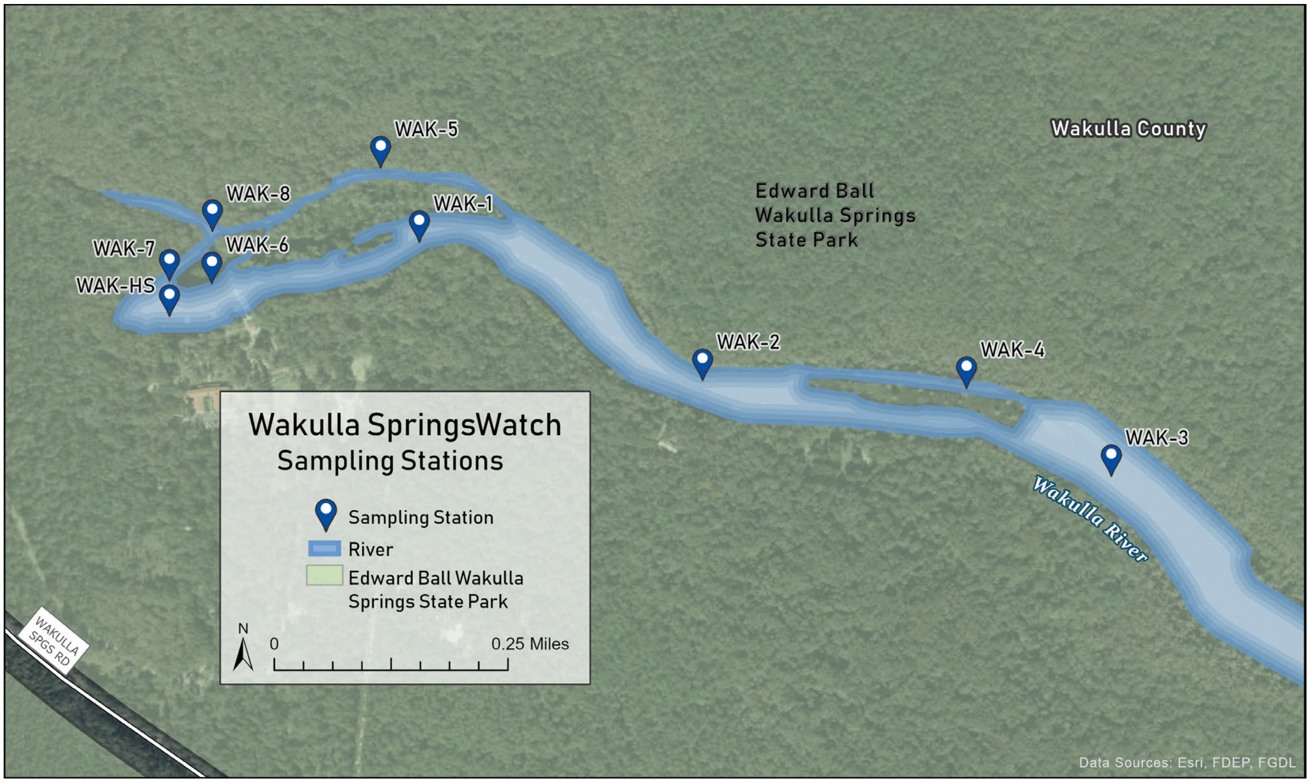


Figure 1. Wakulla SpringsWatch monitoring station map.

Table 1. Coordinates for Wakulla SpringsWatch monitoring stations.

Station Code	Station Name	Latitude	Longitude
WAK-1	WAK-1	30.23587	-84.30107
WAK-2	WAK-2	30.23647	-84.29861
WAK-3	WAK-3	30.23433	-84.29423
WAK-4	WAK-4	30.23285	-84.28791
WAK-5	WAK-5	30.23421	-84.29015
WAK-6	WAK-6	30.2375603	-84.2992201
WAK-7	WAK-7	30.23583	-84.30182
WAK-8	WAK-8	30.23664	-84.30181
WAK-HS	WAK-HS	30.235323	-84.302475

Section 2.0 Methods

SpringsWatch volunteers conducted ecological monitoring at SpringsWatch Springs from January through December 2024. Data collection included water quality field parameters, vertical light attenuation, water clarity, aquatic vegetation photographs, and wildlife counts.

2.1 Sampling Events

Table 2 summarizes the 12 sampling events that occurred in 2024 along the Wakulla River. Monitoring was conducted by SpringsWatch volunteers with assistance from FSI staff.

Wakulla monitoring events include the following:

- Water quality field parameters (temperature, dissolved oxygen, dissolved nitrate-nitrite, and specific conductivity)
- Vertical light attenuation
- Vertical Secchi disk measurements of water clarity
- Aquatic vegetation survey
- Visual bird counts

Table 2. 2024 Sampling Events for Wakulla SpringsWatch

Date	Temperature	Dissolved Oxygen	Specific Conductance	PAR	Nitrate+Nitrite	Secchi	Vegetation	Birds
1/25/2024	X	X	X	X		X	X	X
2/29/2024	X	X	X	X		X	X	X
3/28/2024	X	X	X	X		X		
4/25/2024	X	X	X	X		X	X	X
5/31/2024	X	X	X	X		X	X	X
6/27/2024	X	X	X	X		X	X	X
7/25/2024	X	X	X	X		X	X	X
9/5/2024	X	X	X	X		X	X	X
10/3/2024	X	X	X	X		X	X	X
10/31/2024	X	X	X	X	X	X	X	X
11/27/2024	X	X	X	X		X	X	X
12/26/2024	X	X	X	X		X	X	X

2.2 Water Quality

2.2.1 Dissolved Oxygen and Temperature

SpringsWatch volunteers used a handheld YSI ProODO meter at each of the monitoring stations in the Wakulla Springs System to collect monthly measurements of water temperature and dissolved oxygen at each of the 9 monitoring stations. Lead volunteers calibrated and maintained water quality meters according to manufacturer instructions and Florida Department of Environmental Protection Standard Operating Procedures (FDEP, 2017). If either the initial or post-sampling calibration failed, the associated data were excluded from this report and subsequent analyses.

2.2.2 Specific Conductance

SpringsWatch volunteers used a handheld YSI EcoSense EC300A meter at each of the monitoring stations in the Wakulla Springs System to collect monthly specific conductivity readings at each of the 9 stations along the Wakulla River. Team leaders calibrated and maintained water quality meters according to manufacturer instructions and Florida Department of Environmental Protection

Standard Operating Procedures (FDEP, 2017). If either the initial or post-sampling calibration failed, the associated data were excluded from this report and subsequent analyses.

2.3.1 Nitrate-Nitrite

Nitrate-nitrite samples were taken in October 2024 by FSI staff at station WAK-HS. Water samples were sent to a state-accredited laboratory (McGlynn Laboratories Inc.) for nitrogen as nitrate-nitrite (NOx-N) analysis. Preparation, storage, and analysis all followed FDEP Standard Operating Procedures. Samples were hand collected from approximately 0.1m depth. Sample bottles were re-capped and sealed before being acidified with approximately 0.25mL of 50% sulfuric acid (H2SO4) and then stored on ice prior to transport. Water sampled were held in a refrigerator for <21days before being sent to a state-accredited laboratory (McGlynn Laboratories Inc.) for NOx-N analysis. All analyses were conducted within a standard holding time of 28 days from sample collection.

2.3 Water Clarity

2.3.1 Diffuse Attenuation Coefficient (k) and Percent Transmittance

Photosynthetically Active Radiation (PAR) underwater light transmission and attenuation coefficients were measured monthly at the 9 monitoring sites. Volunteers used a LI-COR brand LI-250A underwater quantum photometer to measure PAR energy reaching the water surface and at depth intervals of one foot and two feet. Figure 2 provides an image of the LI-COR photometer.

Figure 2. LI-COR LI-250A Photometer

2.3.2. Secchi Disk

SpringsWatch volunteers took monthly vertical Secchi disk measurements at Wakulla head spring, station WAK-HS, throughout the sampling period.

The Secchi disk (Figure 3) is a tool for measuring water clarity in aquatic ecosystems. It is a disk with alternating black and white quadrants that is lowered into the water until it is no longer visible. The depth at which the disk disappears is known as the Secchi depth and is used as an indicator of water quality. Secchi length can be used to monitor changes in water clarity over time and can be used to identify problems such as algal blooms or pollution.

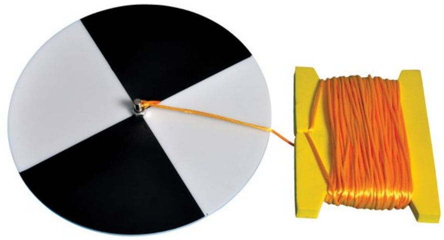


Figure 3. Secchi disk.

2.5 Vegetation

Submerged aquatic vegetation (SAV) was monitored at all 9 stations (Figure 1) during each sampling event. SpringsWatch volunteers took two photographs at each station in two separate locations, which they sent to FSI for vegetation identification. Analysis of vegetative cover was not complete for this report, so photos of typical spring run vegetation are provided instead.

2.6 Bird Surveys

Between January and December 2024, ten bird counts occurred within Wakulla by SpringsWatch volunteers. Wakulla SpringsWatch volunteer recorded visual observations of birds during the entire sampling session.

Section 3.0 Results

This section summarizes field data along the Wakulla River and springs collected from January to December 2024 by SpringsWatch volunteers.

3.1 Water Quality

Figure 4 through 8 present water quality results collected from Wakulla SpringsWatch stations from January to December 2024.

3.1.1 Dissolved Oxygen

A healthy aquatic ecosystem tends to have higher concentrations of DO from atmospheric diffusion and from photosynthesizing SAV and algae, resulting in more oxygen available for uptake by fish and other living organisms. Groundwater typically contains less free oxygen, depending on the duration of time the water has spent underground before emerging from a spring vent.

DO levels fluctuated between spring and river stations primarily due to groundwater vs. surface water influence. Spring stations tend to exhibit lower DO values than river stations since emerging groundwater typically contains less free oxygen depending on the duration of time the water has been underground before reaching a spring vent.

Stations WAK-HS and WAK-7 are closest to the Wakulla Spring vent (Figure 1) and exhibited the lowest DO concentrations. As water moves downstream, its potential to receive oxygen from atmospheric diffusion and from photosynthesizing SAV and algae increases, resulting in higher DO concentrations.

Figure 4 shows dissolved oxygen results measured in percent saturation (DO%). Figure 5 presents DO data measured in milligrams per liter (mg/L), or parts per million (ppm).

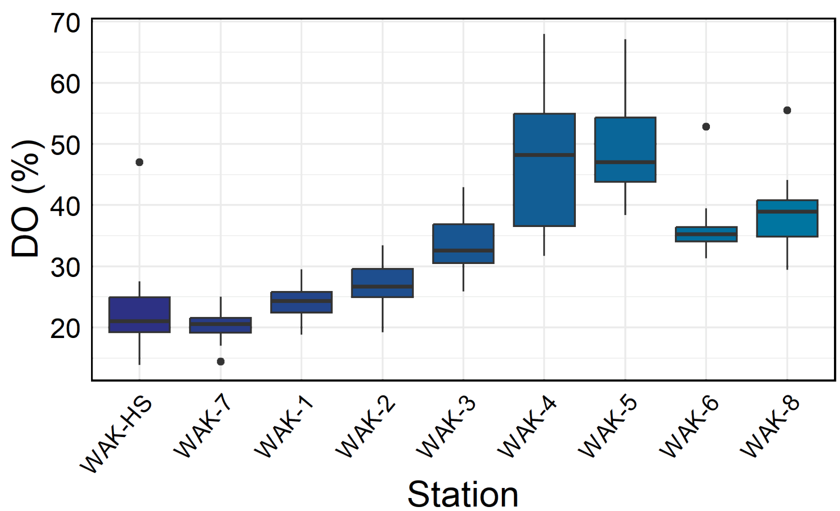


Figure 4. Dissolved oxygen percent saturation (DO%) by Wakulla SpringsWatch station (January-December 2024).

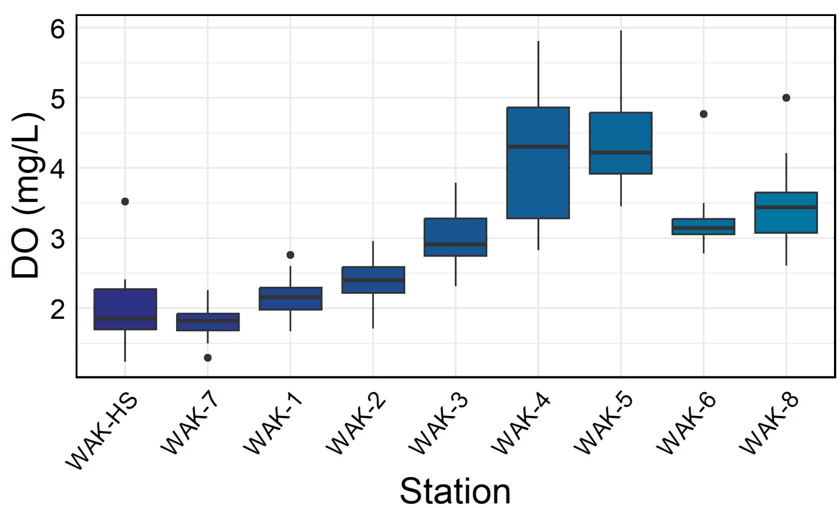


Figure 5. Dissolved oxygen percent saturation (DO mg/L) by Wakulla SpringsWatch station (January-December 2024).

3.1.2 Temperature

Water temperature is relatively constant in Florida springs. However, heavy rain, runoff from land, river flooding, and spring reversals (when surface water flows back into the spring) can disrupt this stability and cause the temperature to fluctuate along the spring run. In Florida, the average temperature from the spring vent is determined by the annual average air temperature and depth of the groundwater source.

Temperature directly affects how much dissolved oxygen the water can hold and how fast plants and animals use energy, their metabolism (Stevens et al., 2002; Hawkins, 1995; Gillooly et al., 2001; Short et al., 2016). The purpose of monitoring water temperature is to indicate any significant changes that may have large effects on other biological and chemical processes in the spring system. Figure 9 presents data for water temperature field measurements.

Figure 6 presents data for water temperature (°C) field measurements by station and by month. Water temperature in Wakulla Headspring, WAK-HS, ranged from 20.1-21.6°C with an average of 21.0°C.

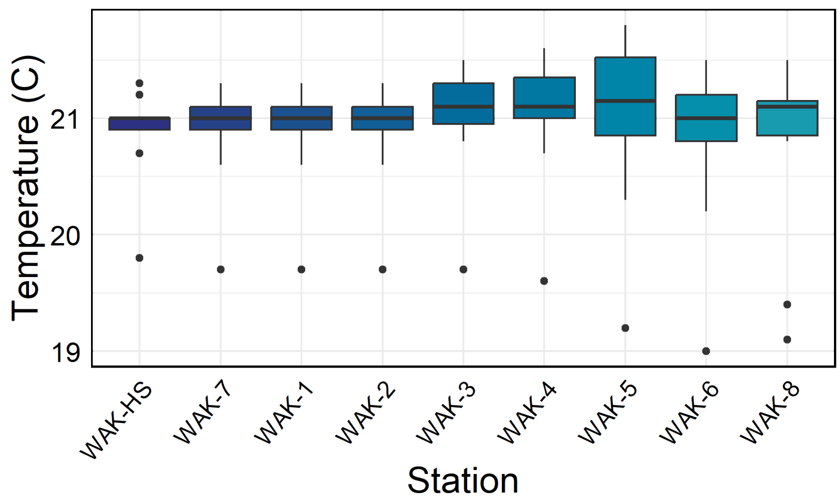


Figure 6. Water temperature (°C) by station for Wakulla SpringsWatch (January to December 2024).

3.1.3. Specific Conductivity

Specific conductance levels can be influenced by naturally occurring ions present in spring water but also from ions present due to higher levels of nitrate/nitrite, saltwater, and other compounds. Higher specific conductance values suggest a higher concentration of these ions in the water. Figure 7 shows specific conductance for the Wakulla SpringsWatch stations.

All the Wakulla stations exhibited periodic elevated specific conductance readings. These readings may be due to backflow of saltwater inland from Springs Creek Springs (Davis and Verdi, 2014). Lower concentrations of specific conductance are a possible indicator of swallet inlets on the edge of the Apalachicola National Forest feeding surface water with elevated tannic color to Wakulla Springs. Evidence for these phenomena is provided in FSI's Wakulla Springs Restoration Plan (FSI 2012).

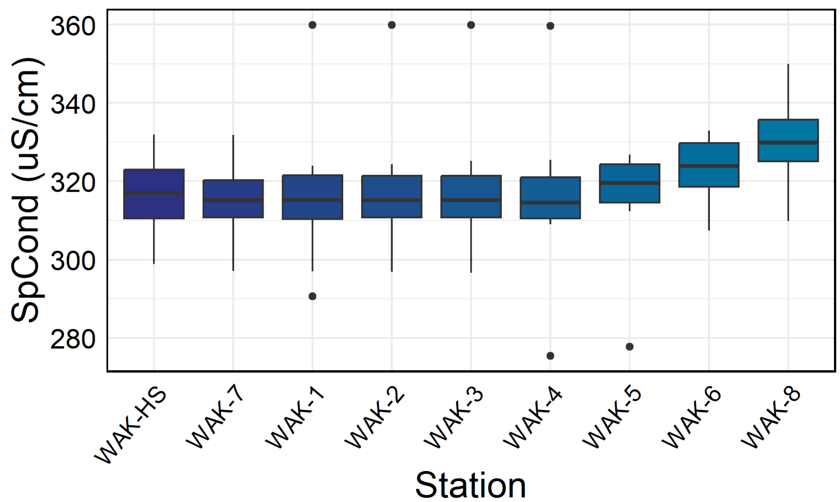


Figure 7. Specific conductance (uS/cm) by Wakulla SpringsWatch station (February-December 2024).

3.1.2. Nitrate-Nitrite

Nitrate and nitrite are forms of nitrogen that move easily through water and are the most common types of nitrogen pollution found in the Floridan Aquifer and many of Florida's springs (Cohen, 2007; Cohen, 2008; Brown et al., 2008; Copeland et al., 2009). This pollution mainly comes from human activities, with the largest sources being fertilizer used in agriculture and landscaping; wastewater from septic systems and treated sewage released into the ground; and animal waste that has not been properly managed (Eller and Katz, 2014; Mattson et al., 2006). High levels of nitrate can negatively impact spring ecosystems in several ways. It has been shown to affect the reproduction of mosquitofish (*Gambusia holbrooki*) (Edwards, 2006; Edwards et al., 2007), increase the growth of phytoplankton and algae (Smith, 2006; Cattaneo and Kalf, 1978; Osborne et al., 2017), worsen the effects of invasive aquatic plants (Wahl et al., 2021), and may contribute to the decline of amphibian populations (Rouse et al., 1999). Because of these risks, FDEP set a springs impairment level of 0.35mg/L in springs vents; suggesting that concentrations above that level may be harmful to the ecosystem (Brown et al., 2008).

FSI staff collected nitrate+nitrite as nitrogen (NOx-N) samples at the Wakulla Headspring (WAK-HS) during the October 2024 sampling session. Figure 8 summarizes 2024 NOx-N data for the SpringsWatch groups that collected these samples; the orange bar highlights the result for Wakulla Headspring. The horizontal red line denotes the 0.35mg/L springs impairment level set by the Florida Department of Environmental Protection (FDEP). NOx-N concentration at WAK-HS was 0.23 mg/L, which is below the set FDEP springs impairment level.

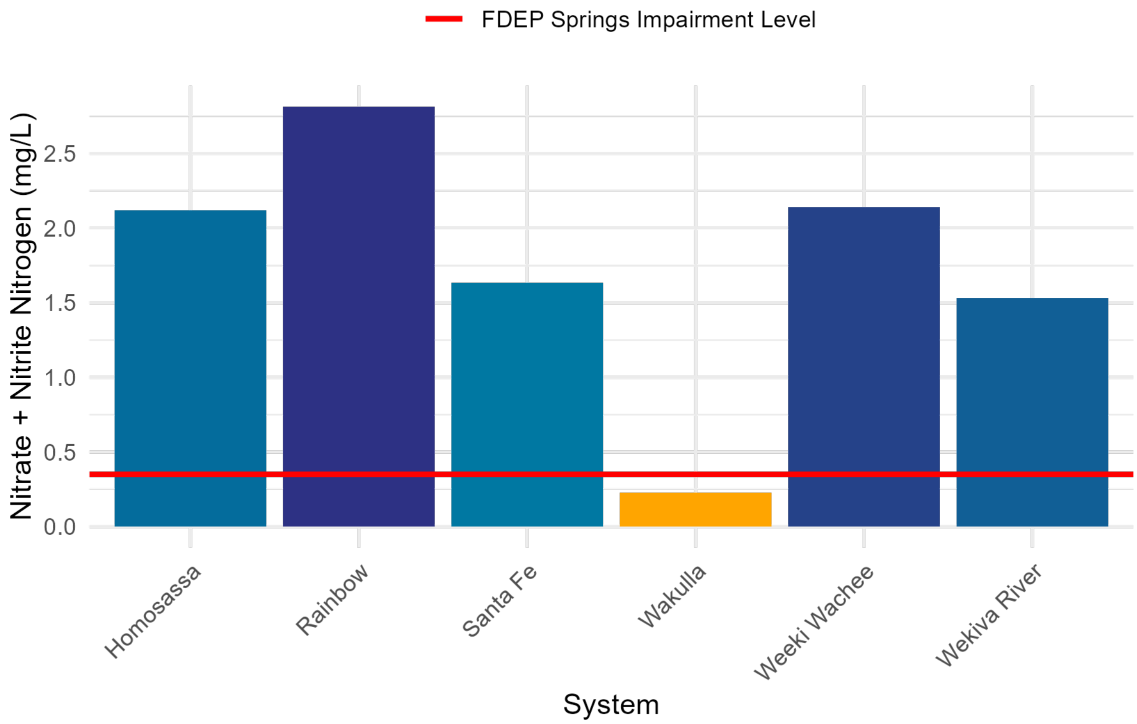


Figure 8. Nitrate+nitrite (NOx-N) levels at SpringsWatch samples sites in 2024. Wakulla is denoted by the orange bar.

3.2 Clarity and Light Measurements

3.2.1 Secchi Disk Visibility

Figure 9 presents vertical Secchi disk measurements in meters at the Wakulla headspring (station WAK-HS) during the sampling period. Secchi data provides additional information concerning water clarity and the light attenuation properties of the spring. Secchi distances ranged from 2.8 meters to 21.7 meters throughout 2024, with an average of 6.7 meters. Lower Secchi measurements indicate reduced water clarity, possibly due to recreational activity and resuspension of algae growing attached to surfaces in the stream channel.

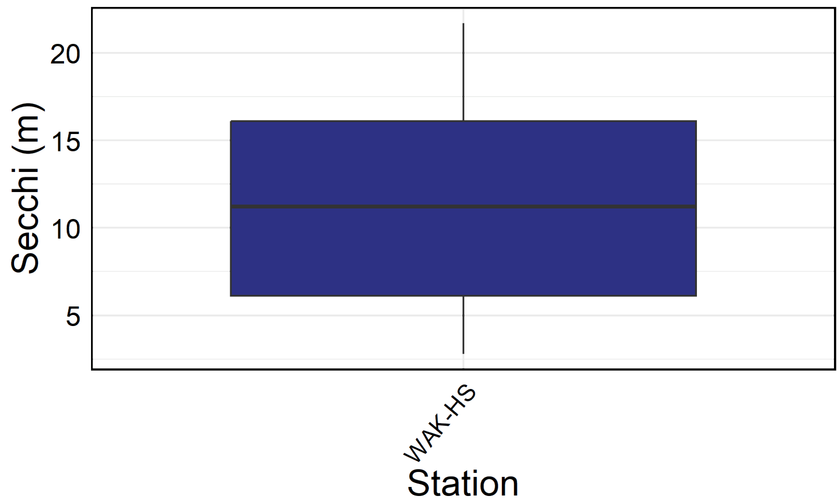


Figure 9. Vertical Secchi disk measurements (m) at Wakulla Spring (WAK-HS) (January-December 2024).

3.2.2 Light Measurements

Figures 10 and 11 present the percent transmittance estimates collected by Wakulla SpringsWatch volunteers from January through December 2024.

Percent transmittance refers to the amount of light that can pass through the water column to a depth of 1 meter below the surface. Figure 11 presents the k (diffuse light attenuation) calculated average per Wakulla SpringsWatch monitoring session (January to December 2024). The diffuse attenuation coefficient (k) is calculated via the Lambert-Beer equation (Wetzel 2001) to measure how readily light dissipates throughout the water column. Higher attenuation values correspond to less water clarity. Higher values of percent transmittance tend to correspond with lower values of coefficient k. Higher k values, or lower percent transmittance values, can indicate poor water clarity since light cannot pass as easily through the water column, often due to increases in dissolved substances such as tannins (color) and suspended solids (turbidity) in the water.

In aquatic ecosystems, the diffusion attenuation coefficient can have a significant impact on the biota that inhabits the water. For example, in shallow, clear water with a low diffusion attenuation coefficient and high percent transmittance, light can easily reach the bottom of the water column, enabling the growth of aquatic plants and phytoplankton. This, in turn, can support the entire food web, from primary producers to top predators. On the other hand, in deep, turbid water with a high diffusion attenuation coefficient and low percent transmittance, light is unable to penetrate as far, limiting the growth of aquatic plants and phytoplankton. This can have cascading effects on the entire ecosystem, potentially reducing the population size and diversity of biota that depend on these primary producers. Thus, the diffusion attenuation coefficient is an important factor to consider when evaluating the health and productivity of aquatic ecosystems.

All the stations had average percent transmittances between about 18.0-28.9%. Combined with the Secchi depth data described above, the continuing impairment of water clarity in Wakulla Spring (WAK-HS) is confirmed. As described by FSI (2012), reduced aquifer pressures in Leon and Wakulla counties due to large groundwater extractions by Tallahassee and in South Georgia have altered the historic movement of groundwaters in the Floridan Aquifer. Wakulla Spring is receiving an increased share of tannic groundwaters from the Apalachicola National Forest that in the past flowed south to Springs Creek. Increased tannic water is presumed to be the cause of reduced water clarity in Wakulla Spring.

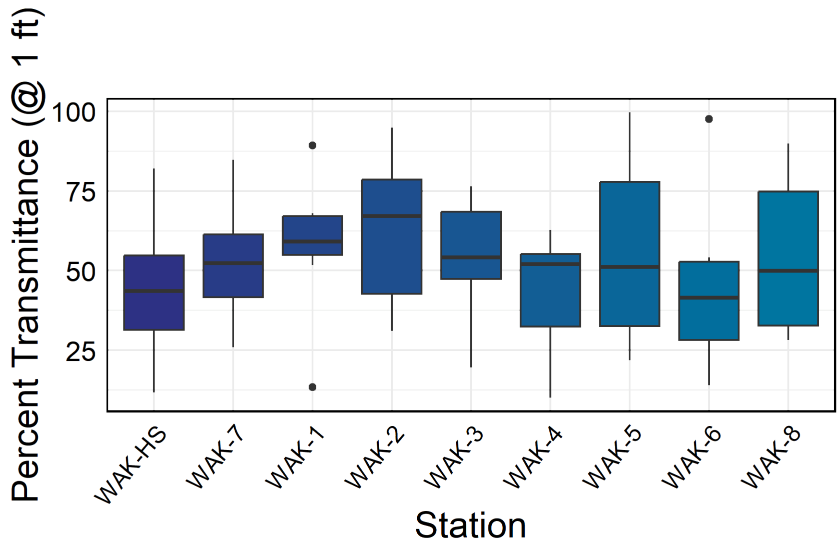


Figure 10. Percent transmittance (@ 1ft) for Wakulla SpringsWatch (January–December 2024).

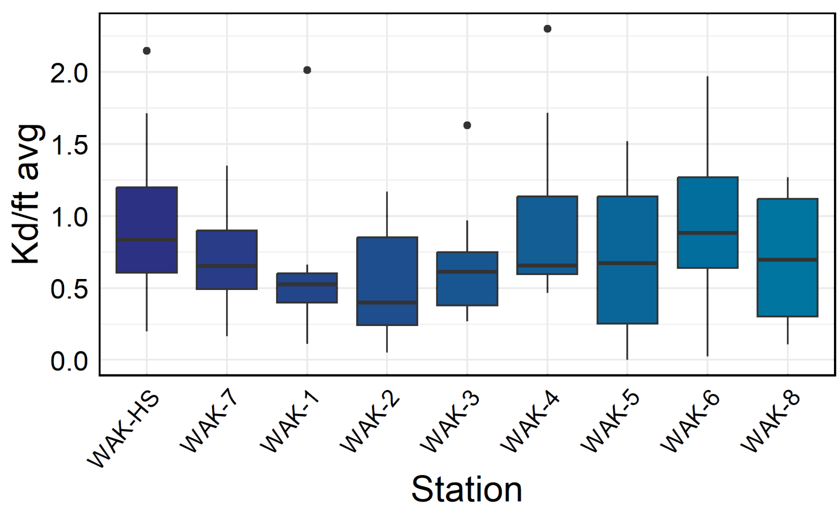


Figure 11. k (diffuse attenuation coefficient) by Wakulla SpringsWatch station (January - December 2024).

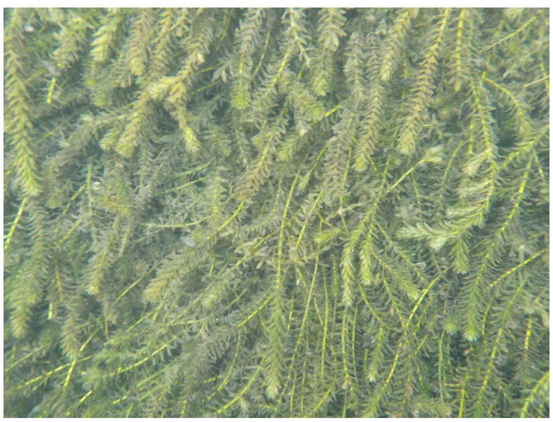
3.3 Aquatic Vegetation Survey

Submerged aquatic vegetation plays an important ecological role within a springs system. It provides habitat and food for fish and other wildlife, increases water clarity, affects nutrient cycles, and stabilizes shorelines and sediments. This data presents an ongoing record of conditions in the river and spring and will be useful for comparison to future evaluations of the ecological health of the Wakulla system.

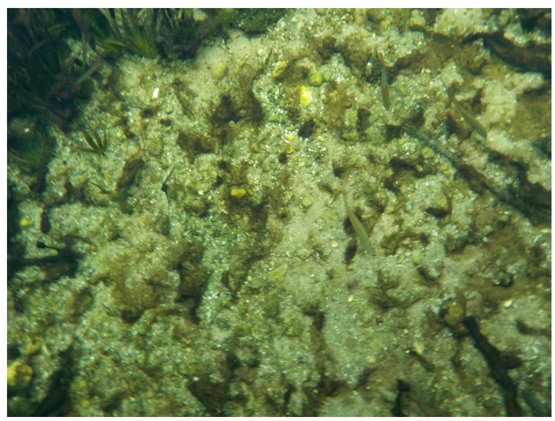
Pictured below are photos taken by SpringsWatch volunteers during the September 2024 survey (Table 2) which feature the SAV of the Wakulla River and springs.

WAK-1: Vallisneria and algae

WAK-3: Hydrilla, sand, and shell



WAK-4: Hydrilla



WAK-7: Vallisneria, algae, sand, and limestone

3.4 Bird Survey

Wakulla SpringsWatch volunteers recorded visual monthly observations of birds between stations all stations (Figure 2). Table 3 presents a summary of birds observed during monthly outings except the March 2024 survey date (Table 2) total, 22 species were observed. Black vultures were the most observed species.

Table 3. Summary of birds observed during eleven outings between January – December 2024.

Common Name	Scientific Name	Average of Count
Anhinga	*Anhinga anhinga*	8
Belted Kingfisher	*Megaceryle alcyon*	1
Black Vulture	*Coragyps atratus*	43
Cattle Egret	*Bubulcus ibis*	4
Common Moorhen	*Gallinula chloropus*	30
Crow	*Corvus sp*	5
Double Crested Cormorant	*Phalacrocorax auritus*	7
Great Blue Heron	*Ardea herodias*	2
Great Egret	*Ardea alba*	2
Green Heron	*Butorides virenscens*	1
Hooded Merganser	*Lophodytes Cucullatus*	38
Least Bittern	*Ixobrychus exilis*	1
Little Blue Heron	*Egretta caerulea*	5
Osprey	*Pandion haliaetus*	2
Pied Billed Grebe	*Podilymbus podiceps*	2
Red Shouldered Hawk	*Buteo lineatus*	1
Roseate spoonbill	*Platalea ajaja*	1
Snowy Egret	*Egretta thula*	1
Tricolored Heron	*Egretta tricolo*	1
White Ibis	*Eudocimus albus*	33
Wood Duck	*Aix sponsa*	7
Yellow-Crowned Night Heron	*Nyctanassa violacea*	5

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Section 5.0 Appendix

Table A.1. Data collected from Wakulla SpringsWatch Group January to December 2024

Station	Parameter Name	Average	Number of Samples	Maximum	Minimum	Standard Deviation
WAK-1	Dissolved Oxygen (%)	24.1	12	29.5	18.8	3.3
	Dissolved Oxygen (mg/L)	2.1	12	2.8	1.7	0.3
	Specific Conductance (µS/cm)	316.3	12	359.9	290.7	17.0
	Temperature (°C)	20.9	12	21.2	20.1	0.3
	k (diffuse attenuation coefficient)	0.7	7	2.0	0.1	0.6
	Percent Transmittance (@ 1 ft)	57.9	7	89.3	13.4	23.0
WAK-2	Dissolved Oxygen (%)	26.7	12	33.4	19.2	3.8
	Dissolved Oxygen (mg/L)	2.4	12	3.0	1.7	0.3
	Specific Conductance (µS/cm)	318.2	12	359.9	296.9	15.1
	Temperature (°C)	21.0	12	21.3	20.1	0.4
	k (diffuse attenuation coefficient)	0.5	9	1.2	0.1	0.4
	Percent Transmittance (@ 1 ft)	63.3	9	94.8	31.1	23.8
WAK-3	Dissolved Oxygen (%)	33.6	12	42.9	25.9	5.2
	Dissolved Oxygen (mg/L)	3.0	12	3.8	2.3	0.5
	Specific Conductance (µS/cm)	318.2	12	359.9	296.6	15.1
	Temperature (°C)	21.0	12	21.5	20.1	0.4
	k (diffuse attenuation coefficient)	0.7	10	1.6	0.3	0.4
	Percent Transmittance (@ 1 ft)	55.1	10	76.5	19.6	18.0
WAK-4	Dissolved Oxygen (%)	46.9	12	68.0	31.7	11.7
	Dissolved Oxygen (mg/L)	4.2	12	5.8	2.8	1.0
	Specific Conductance (µS/cm)	316.0	12	359.6	275.5	18.6
	Temperature (°C)	21.2	12	22.0	20.2	0.5
	k (diffuse attenuation coefficient)	1.0	10	2.3	0.5	0.6
	Percent Transmittance (@ 1 ft)	43.4	10	62.8	10.0	18.3
WAK-5	Dissolved Oxygen (%)	49.8	12	67.1	38.4	9.5
	Dissolved Oxygen (mg/L)	4.4	12	6.0	3.5	0.8
	Specific Conductance (µS/cm)	316.5	12	326.8	277.8	13.1
	Temperature (°C)	21.1	12	21.9	20.2	0.6
	k (diffuse attenuation coefficient)	0.7	8	1.5	0.0	0.6
	Percent Transmittance (@ 1 ft)	55.4	8	99.7	21.9	28.9
WAK-6	Dissolved Oxygen (%)	36.4	12	52.8	31.3	5.6
	Dissolved Oxygen (mg/L)	3.3	12	4.8	2.8	0.5
	Specific Conductance (µS/cm)	323.0	12	332.9	307.4	7.4
	Temperature (°C)	21.0	12	21.7	20.3	0.5
	k (diffuse attenuation coefficient)	1.0	9	2.0	0.0	0.6
	Percent Transmittance (@ 1 ft)	43.1	9	97.7	14.0	24.4

Table A1. Continued

Station	Parameter Name	Average	Number of Samples	Maximum	Minimum	Standard Deviation
WAK-7	Dissolved Oxygen (%)	20.2	12	25.0	14.4	2.8
	Dissolved Oxygen (mg/L)	1.8	12	2.3	1.3	0.3
	Specific Conductance (µS/cm)	315.6	12	331.8	297.2	8.6
	Temperature (°C)	20.9	12	21.2	20.1	0.3
	k (diffuse attenuation coefficient)	0.7	8	1.3	0.2	0.4
	Percent Transmittance (@ 1 ft)	52.3	8	84.8	25.9	20.1
WAK-8	Dissolved Oxygen (%)	39.0	12	55.5	29.4	6.9
	Dissolved Oxygen (mg/L)	3.5	12	5.0	2.6	0.7
	Specific Conductance (µS/cm)	329.3	12	350.0	309.9	11.5
	Temperature (°C)	21.1	12	22.0	20.4	0.5
	k (diffuse attenuation coefficient)	0.7	7	1.3	0.1	0.5
	Percent Transmittance (@ 1 ft)	54.7	7	89.9	28.1	25.7
WAK-HS	Dissolved Oxygen (%)	23.1	12	47.0	13.9	8.5
	Dissolved Oxygen (mg/L)	2.0	12	3.5	1.2	0.6
	Secchi	11.3	9	21.7	2.8	6.7
	Specific Conductance (µS/cm)	316.9	12	332.0	298.8	9.1
	Temperature (°C)	21.0	12	21.6	20.1	0.4
	k (diffuse attenuation coefficient)	1.0	8	2.1	0.2	0.6
	Percent Transmittance (@ 1 ft)	43.5	8	82.0	11.7	22.7